United States
Department of
Agriculture

Forest Service

Forest Pest
Management

Davis, CA.

AGDISP

Evaluation and Validation Training User Group Code Enhancements

September 20, 1989

A Meeting to Discuss Technology Transfer and Evaluation of AGDISP

FPM 90-1
March 1990

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Transfer and Evaluation of AGDISP

Prepared by:

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(Prepared under Contract No.
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PREFACE

This report summarizes discussions of a meeting to discuss the AGDISP (agricultural dispersal) aerial spray model, held at the USDA Forest Service (FS) offices in Rossyln, Virginia on September 20, 1989. It also contains an outline of a talk on AGDISP that was presented by Milton Teske of Continuum Dynamics, Incorporated at the meeting.

BACKGROUND AND DISCUSSION

Since 1970 the FS, in cooperation with the U.S. Army, has been developing computer models that predict the movement, dispersion, and deposition of aerially released sprays. Two models have been the focus of this cooperative work - FSCBG (Forest Service Cramer-Barry-Grim) and AGDISP (Agricultural Dispersal). Both are in the process of being transferred to the user community world-wide. Each model has a system manager who is responsible for user input, maintenance, training, and model enhancement. In addition the FS has entered into a Memorandum of Understanding with Continuum Dynamics, INC. (CDI) to administer two user groups, one for each model. Maintaining the integrity of these models is a concern to both system managers.

On September 20, 1989 a meeting was held at Rosslyn, VA to discuss ways to further coordinate the evaluation, enhancement, and technology transfer of AGDISP with others who have expressed interest in the model. FSCBG was also discussed within this context. The meeting was attended by:

Jack Barry	USDA Forest Service, WO-FPM (Davis, CA)
Baozhong Duan	Pennsylvania State University (University Park, PA)
Bob Ekblad	USDA Forest Service,MTDC (Missoula, MT)
Harold Flake	USDA Forest service, R-8 (Atlanta, GA)
Dave Miller	University of Connecticut (Storrs, CT)
Max Ollieu	USDA Forest Service, WO-FPM (Washington, DC)
Dick Reardon	USDA Forest Service, NA-AIPM (Morgantown, WV)
Pete Rush	USDA Forest Service, NA (Morgantown, WV)
Milt Teske	Continuum Dynamics, INC (Princeton, NJ)
Bill Yendol	Pennsylvania State University (University Park, PA)

Bob Ekblad presented an historic overview of the FS aerial spray model development; Milt Teske reviewed the AGDISP code's construct and model evaluation; and Dick Reardon briefly discussed the NA-AIPM cooperative agreements with Pennsylvania State University and University of Connecticut for model evaluation. A dialogue continued on these matters until late afternoon, culminating with a proposal that a national advisory committee be established to coordinate the interests and needs of organizations and individuals that have an interest in aerial spray models. The committee would be made up of persons who have funds or authority to commit funds to support the models. Jack Barry volunteered to take the lead in developing a proposal to establish a national advisory committee for aerial spray models. The proposal is included in this report.

The matter of using AGDISP to predict spray aircraft swath widths also was discussed at some length. The discussions included technical, political, geographical, and management issues. NA-AIPM, through their cooperative agreement with Pennsylvania State University, has contracted the University to use AGDISP to predict the swath width of 15 spray aircraft. NA, on a related but separate action, is preparing a listing of spray aircraft swath width needs that will be addressed by ADGISP before the 1990 spray season. The list will

[illegible]

the FS, in cooperation with the U.S. Army [illegible] that predict [illegible] Minnesota [illegible] and [illegible] The models have been the [illegible] (Forest Service Cramer-Barry-Grim) and [illegible]. Both are in the process of being [illegible] wide. Each model has a system [illegible] [illegible] licensing, training, [illegible] a Memorandum of Understanding [illegible] [illegible] two user groups, [illegible] for each [illegible] [illegible] models is a [illegible] managers.

September [illegible], 1989 a meeting [illegible] [illegible] coordinate the [illegible] [illegible] with others who have [illegible] [illegible] within this context. The [illegible]

Jack Barry	USDA Forest [illegible]
[illegible] Duan	[illegible] State [illegible]
[illegible] Ekblad	[illegible]
Harold Fless	[illegible], Fort [illegible]
Dave Miller	University of Minnesota [illegible]
Max Olliers	[illegible] Forest [illegible]
Dick Reardon	USDA Forest Service
Pete Rush	USDA Forest Service [illegible]
Milt Teske	Continuum Dynamics, INC [illegible]
Bill Yendol	Pennsylvania State University

Bob Ekblad presented an historic overview [illegible] development; Milt Teske reviewed the AGDISP code [illegible] [illegible]; and Dick Reardon briefly discussed [illegible] [illegible] with Pennsylvania State University [illegible] [illegible] evaluation. A dialogue continued on [illegible] [illegible] with a proposal that a national [illegible] coordinate the interests and needs of [illegible] [illegible] an interest in aerial spray models [illegible] persons who have funds or authority to [illegible] Jack Barry volunteered to take the lead in developing [illegible] national advisory committee for aerial spray models [illegible] [illegible] report.

[illegible] of using AGDISP to predict [illegible] [illegible] at some length. The discussions included technical, political, [illegible] management issues. [illegible] Pennsylvania State University, [illegible] predict the swath width of [illegible] spray aircraft [illegible] [illegible] preparing a listing of spray aircraft [illegible] [illegible] by AGDISP before the 1990 spray season. [illegible]

be forwarded by NA to WO-FPM requesting assistance in running the model. It was proposed that the FS identify a detailer, possibly Tim McConnell, to work with Continuum Dynamics, INC in running the AGDISP to satisfy the NA requirement. Specifically NA will send a letter to Jack Barry that specifies the spray aircraft and combination of variables for which AGDISP swath width predictions are needed. Bob Ekblad will then arrange for a detailer and coordinate with Continuum Dynamics, INC to do this work. The work will probably be done under a purchase order with funds being provided by NA. Bob will take the overall lead on this project with Jack Barry providing coordination as needed.

PROPOSAL - SPRAY MODEL ADVISORY COMMITTEE

At a recent USDA Forest Service (FS) sponsored meeting of persons interested in the FS's aerial spray models it was suggested that a national spray model committee be established. The referenced meeting was held on September 20, 1989 in Rosslyn, VA to discuss interests and needs of various parties in aerial spray models. This paper outlines the purpose, scope, sponsorship, membership, and responsibilities of the proposed committee. The FS believes that other organizations that might benefit from the aerial spray models that were developed by the FS and the U.S. Army, should contribute to future evaluations and enhancements to the models.

The proposed committee would be supplemental to the spray model system managers and the user group. The system manager (one for each of the two models) is the focal point for all actions involving changes to the model. The user group (one for each model) is the focal point for communicating to model users. The user groups communicate and the system managers manage.

Committee Name: National Advisory Committee for Aerial Spray Models

Purpose of Committee: The purpose of the committee is to provide recommendations to the system managers to further the maintenance, evaluation, enhancement, and technology transfer of the FS's aerial spray models.

Scope: The scope of the Committee's responsibility will include identifying and establishing priorities for model evaluation, enhancement, and technology transfer, and submitting recommendations to system managers.

Sponsorship: The Committee shall be sponsored by (FS) WO-FPM and WO-ENGR and co-sponsored by any public or private organization that may commit resources to support the Committee's recommendations.

Membership: Membership shall include managers, researchers, and operational users from FS; other Federal agencies to include but not limited to U.S. Army, US-EPA, USDA-ARS, and USDA-APHIS; States; industry; universities; and administrators of the user groups. Organizations represented on the Committee shall be potential sources of funding. These organizations should be prepared to support their respective member's travel and salary incidental to Committee business.

Responsibilities: The sponsor (FS) shall administer the Committee and appoint a chairman. The Committee will meet annually, or as frequently as the Committee deems necessary, and submit its recommendations to the system managers by April 1st.

[illegible] SURVEY [illegible]

[illegible] Forest Service (FS) [illegible]
[illegible] This works [illegible] models is [illegible]
[illegible] can be [illegible] tabulated [illegible]
[illegible] Rosslyn, VA [illegible]
[illegible] els. This paper [illegible]
[illegible] responsibilities of the proposed [illegible]
[illegible] those that might benefit [illegible]
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[illegible] ed committee would [illegible]
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[illegible] for all [illegible]
[illegible] model [illegible]
[illegible] group [illegible] model [illegible]

[illegible] Note [illegible]

[illegible]
[illegible] contributions to [illegible]
[illegible] ment, and [illegible]

[illegible] The group of the committee [illegible]
[illegible] establishing priorities [illegible]
[illegible] est, not [illegible]

[illegible] Committee sh [illegible]
[illegible] any public or private [illegible]
[illegible] the Committee [illegible]

[illegible] Membership shall [illegible] however [illegible]
[illegible] FS, [illegible] federal agencies to include [illegible]
[illegible] EPA, USDA ARS, or USDI NBS [illegible]
[illegible] of the user groups. [illegible]
[illegible] be potential sources of funding. [illegible]
[illegible] meet their respecti [illegible] travel [illegible]

[illegible] responsibilities. The sponsor (FS) shall [illegible]
[illegible] The Committee will meet annually, [illegible]
[illegible] as necessary, and submit its [illegible]
[illegible] by April 1st.

AGDISP - A Briefing by Milton Teske

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Transfer and Evaluation of AGDISP

Milton Teske
Continuum Dynamics, Inc.

AGDISP

An engineering model (not a research code) that predicts the behavior of spray material:

Released through nozzles into the wake of a spray aircraft (either fixed-wing or helicopter);
Traveling through real atmospheric effects;
Penetrating canopy (trees or crops); and
Impacting the ground.

Validated against existing field test data; combines many engineering approximations that have themselves been validated by laboratory experiments.

Needs the following information to compute a spray scenario:

Meteorological conditions anticipated during spraying (temperature, relative humidity, wind speeds);
Aircraft information (weight, wingspan, speed, altitude);
Nozzle information (number, placement, flow rate);
Spray material information (composition, drop size distribution, volatility);
Mission scenario (number of passes, length of passes, direction); and
Canopy information (height, types of trees, "density").

AGDISP Mod 5.1

Under development since 1979.

Predicts the motion of aerially released material, including the mean position of the material and the position variance about the mean as a result of turbulent fluctuations.

Solves for the near-aircraft detailed effect of the aircraft wake on the behavior of released spray material.

Lagrangian solution approach: it follows the droplets as they move in the wake of the aircraft.

Includes models for:

Wing-tip vortices
Helicopter downwash and forward flight
Jet engines and propellers
Atmospheric crosswind
Vortex circulation strength decay
Turbulence
Evaporation
Canopy structure and penetration
Ground and canopy deposition

Operational on:

IBM personal computers and compatibles
USDA Forest Service Data General system

AGDISP Modeling

Engineering models in AGDISP have been borrowed from several aircraft and atmospheric approximations:

Wing tip vortex pair behavior discussed by Lamb (1879)
Decay coefficient deduced from Program WIND (1985-86)

Lagrangian solution scheme demonstrated by Reed (1953)
Semi-empirical drag law by Langmuir and Blodgett (1946)
Turbulent correlation equations from second-order closure turbulence modeling by Donaldson (1973)
Simple evaporation by Trayford and Welch (1977)

Helicopter downwash from actuator disk theory by Rankine (1860)
Coupled to vortex pair growth verified by rollup in a complex helicopter wake by Quackenbush (1984)

Jet engines and propellers modeled as circular jets from Schlicting (1951)
Turbulence from experiments by Wygnanski and Fiedler (1969)

Neutral atmospheric boundary layer logarithmic following Monin and Obukhov (1954)
Consistent turbulence from second-order closure (1978)

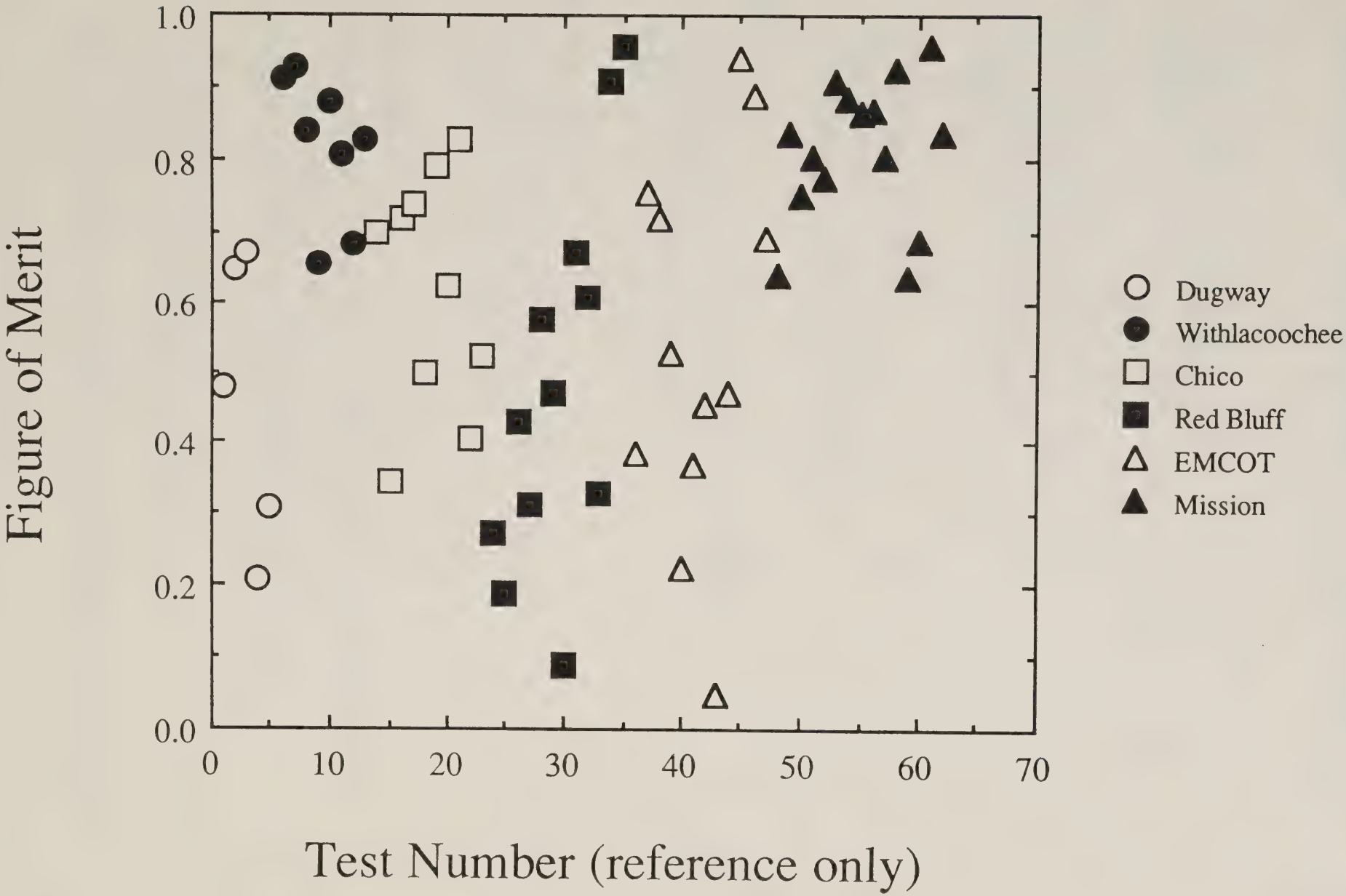
Canopy effects modeled from experiments by Wilson and Shaw (1977)

Deposition assumed Gaussian (the beginning of time)
Continuous deposition model developed by Bliss (1984)
Object deposition from Golovin and Putnam (1962)

SUMMARY OF SPRAY DEPOSITION STUDIES USED TO VALIDATE AGDISP

Location	**Chico**	**Dugway**	**EMCOT**	**Mission**	**Red Bluff**	**Wallops**	**Withlacoochee**
Date	1985	1974	1986	1987	1986	1981	1980
Aircraft	AgCat Hiller 12E	DC-7B	Bell 206	AgTruck	C-130 Bell 206	Ayres Thrush	Stearman Hughes 500C
Runs	10	5	4	21	12	83	8
Passes per Run	6	1	1	1	1 to 10	1	7 to 10
Altitude (m)	12.2	27 to 52	12.7 to 23.5	15.6	15.2 to 76.2	3 to 4	14.6 or 18.8
Nozzles	6 28	150	22	47	50 or 64 34	2	27 48
Spray Rate (gal/min)	20.5 5.4	25 or 26	19.4	18.2	116 or 149 12.2	--	27.3 7.6
VMD (microns)	189 251	50 to 68	390	149	394 264	300, 600 (beads)	350 350
Conditions	almond orchard	open field	open terrain	open field	forested	open field	seed tree orchard

AGDISP Comparisons



AGDISP Validation Assumptions

1974 Dugway
- Nominal roughness height
- VMD

1980 Withlacoochee
- Homogeneous slash pine canopy
- Nominal roughness height
- VMD

1981 Wallops (NASA)
- Glass beads clogged exit ports
- Integrated deposition ratioed

1985 Chico
- Homogeneous almond orchard canopy
- Nominal roughness height
- VMD

1986 Red Bluff
- Homogeneous ponderosa pine canopy
- Nominal roughness height
- VMD

1986 EMCOT
- No evaporation but so little collected that integrated deposition ratioed
- Helicopter pilot did not create a line source

1987 Mission (Fixed Wing)
- Collection efficiency on elevated cards
- Volatility
- Aircraft altitude (fluctuates up to 20 percent of mean)

AGDISP Validation Difficulties

Early tests did not anticipate inputs to AGDISP

Quantify crosswind velocity as a function of height
- One meteorological tower
- Surface roughness
- Turbulence

Line source

Aircraft characteristics
- Height
- Position relative to card line

Small drops are a problem to collect and count

Spread factors
- Integral of ground deposition

Wet cards

Locate cards under canopy

Homogeneity

Evaporation effects

Sensitivity study

AGDISP Events

We have been able to identify the key variables and processes that most directly influence the behavior of spray in the wakes of aircraft.

We have been able to approximate these effects with simple models that do not require significant computer time to solve for them, or a high skill level to understand the code and exercise it.

AGDISP is operational on the USDA Forest Service Data General system and on personal computers.

Two training sessions have been conducted in Missoula, MT on the operation of the model (Nov. 15-18, 1988 and March 28-31, 1989). A next training session has been tentatively scheduled for Nov. 28 - Dec. 1, 1989 (Morgantown, WV). Texas A&M and Dupont may also be sponsoring in-house training sessions later this year or early next.

The USDA Forest Service and Continuum Dynamics, Inc. have entered into a Memorandum of Understanding to promote and support AGDISP.

The AGDISP User Group currently has 16 members from government and industry, in the United States and Canada.

Users at training sessions have suggested several improvements to the code, which can only enhance its usefulness.

AGDISP User Group Membership

USDA Forest Service

Jesus Cota
Robert Ekblad
Harold Flake
Sandy Gast
Buddy Kirk
Tim McConnell
Larry Stipe

Trainees

Jack Barry
Ed Monnig
Jose Negron
Lundy O'Dell
Dick Reardon
Pat Skyler
Julie Weatherby

University

Brian Cleary	Oregon State
Joel Walker	Arkansas
Wes Yates	UC Davis and Failure Analysis, Inc.
Bill Yendol	Penn State

Private

Robert Bird	ETI, Inc.
Jeff Falini	E. I. Dupont Company, Inc.
John Weeks	Labat-Anderson, Inc.

Other

Bob Mickle	Atmos Envir Service (Canada)
Bruce Johnson *	Calif Dept of Food and Ag

Proposed AGDISP Enhancements

Deposition of nonvolatiles

Extend atmospheric model to nonneutral conditions

Dry materials option

Data validation of canopy and collector deposition

Complex terrain interface

Toolkit for **power users**

User friendly front end editor to construct data input files

Multiple drop sizes in one data input file

Specific program enhancements suggested by training session attendees

Printer driver for personal computers with HP plotters

Data input sensitivity study

Analyze Mission helicopter data

Update user manual

Update Data General version at Missoula, MT

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